MOSQUITO REDUCTION AND MALARIAL PREVENTION

DE CRIPTIVE DIAGRAM *ANOPHELES* (FEMALE)

MOSQUITO
Reduction and
MALARIAL
Prevention

A PRECIS

BY

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AND

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THIS BOOK IS DEDICATED

TO

LT COLONEL S R CHRISTOPHERS F R S C I E O B E I M

FOREWORD

THE Authors of this small book are quite correct when they point out the need of a work such as they now put forward. Many books it is true deal with anti-malarial work and many with various aspects of the study of malaria entomological, parasitological, clinical, etc. There are also general treatises on malaria and works on the practical prevention of the disease. But the fact remains that it is very difficult to recommend a book to a beginner that will give him the simple facts and interests he requires to help him in commencing actual practical work in the field. The Authors have met the needs of a manager of a tea garden or a malarial inspector or the N.C.O. in charge of a regimental sanitary squad from their own experience of what such persons require. They give a brief but sufficient account of the nature of malarial fever, of the chief facts about mosquitoes and of how to find and identify mosquitoes, especially the Indian species of malaria carriers. They end with an account in some detail of practical steps to be taken in prevention and in the form of appendices, with some helpful

notes on the technique connected with mounting and preserving specimens The Authors themselves have had the practical experience that qualifies them to write helpfully for others and I wish their venture every success

S R CHRISTOPHERS

PREFACE

THE Authors in placing before the public this volume do so with the hope of filling a need long felt by the worker and inspector in anti malarial measures There are at present many tomes and excellent treatises dealing exhaustively with the life habits and elimination of mosquitoes and many are written with a view to controlling yellow fever and malaria—but the man who is too busy in other walks of life or who has not the necessary technical education cannot readily acquire the knowledge contained in these We have only introduced such technical names and phrasing in this book as are absolutely necessary for the proper understanding of the subject and where these are introduced they are explained as simply as possible It has been our experience that the manager of a tea garden or a malarial inspector or the N C O in charge of a sanitary squad dealing with anti malarial measures begins to take a much keener interest in his work when he has acquired some knowledge of the habits and life history of the mosquito and it is primarily in the hope of quickening their interest that this work has been undertaken

Our thanks are due to Lt Colonel S R Christophers F R S C I E O B E I M S for his kindness in reading through our work and for his many valuable criticisms and also for allowing us to include a Synoptic Table of Indian *Anophelini* issued by the Central Malarial Bureau Kasauli 1926 We also desire to thank all who by their kind criticism have encouraged us in our work

BOMBAY
June 1926

J A C
B S C

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CHAPTER I

THE FACTORS CAUSING MALARIA

MALARIA is probably the commonest disease that affects mankind and its ravages are spread over large areas of the world Nor is it a disease of comparatively recent origin for we find reference to it in the writings of ancient Greece and Rome Its ravages are evidenced in manifold directions for not only does it in certain instances destroy the life of the individual infected but also from its chronic nature, debilitates him and thus exposes the unfortunate person to attacks of other and more grave disorders In India alone it is estimated that some four millions of people apply annually for treatment for malaria and there must be many others who do not apply for treatment If we add to that number the vast army of sufferers outside India we shall have some idea of the widespread character of this disease

The economic and financial loss which arises as a direct and indirect result of the ravages of malaria can only be touched upon here Many a day's labour is lost to those who employ people suffering from this disease and the employees themselves broken in health by recurring bouts

of fever cannot be productive of the same amount or of as high a quality of work whether mental or physical as those who labour under conditions where malaria does not exist The financial loss to the employers of labour in malarious districts is immense and in this direction one cannot but refer the reader to the literature dealing with the subject If this disease were to be eliminated the gain to mankind from a humanitarian and economic stand point would be beyond belief and it is from this point of view that we must approach the subject We must first of all try to discover what essential factors are necessary to bring about this disease and where if possible we can break in upon and destroy either all or one of these factors

As we have already mentioned this disease is to be found described by the ancient Greek and Latin authors and even in those days the relation ship between marshes and malaria was recognized In the middle ages a type of mosquito net was mentioned as the only safeguard to those living near marshes This would seem to correlate for the first time fever marshes and insects

The next real advance made was the discovery of Cinchona By its use the physicians in the eighteenth century were able to distinguish between those fevers which reacted to Cinchona (i e quinine) and those that did not

The name Malaria is derived from two Italian words 'Mal and Aria meaning bad air and refers to the belief that the cause of the condition was due to bad air arising from marshes

It was not however until 1881 that the really first big step was made in solving the problem of its cause In that year the French surgeon Laveran demonstrated that malaria was caused by a minute organism which attacked the blood corpuscles Following quickly upon this the workers in the subject established three distinct organisms which caused three distinct types of fever These organisms are called *Plasmodium vivax* which causes Benign tertian malaria *Plasmodium malariae* which causes Quartan malaria and *Plasmodium falciparum* which causes Malignant malaria

Up to this time we had two of the three great factors in this disease—namely man and the plasmodium Having found that malaria was caused by these organisms it yet remained to be discovered how man became infected or how the disease spread and it was not until 1898 that Sir Ronald Ross working on a hypothesis put forward by Manson demonstrated that mosquitoes spread the disease from man to man by their bites Thus were the three great factors man mosquito and plasmodium linked up and the cause and method of spread of malaria definitely settled

In order that we may arrive at a full comprehension of the manner in which these three factors are linked together we must have a knowledge of how the plasmodia infect man

We will consider the plasmodium itself This organism comes very low in the scale of animal life seeing that it consists of one cell only It is classed as a Protozoon The substance called protoplasm of which this unicellular organism is composed has the same properties as have cells used in building up the tissues of higher animals that is to say it grows moves assimilates food and reproduces itself by division Its reproduction is of two distinct types asexual and sexual It also has the power of producing a variety of chemical substances The organism itself has a nucleus situated in the midst of protoplasm which is the substance of which all living cells are built up In its methods of living it is entirely parasitical that is to say it lives at the expense of other animals which are called its hosts Like all true parasites the plasmodia must adapt themselves to life inside their hosts and must be able in order that the species may be maintained to pass from one host to another Thus it is that the parasites grow and multiply by one method in one host—man—and by another method in mosquitoes The former is called the

asexual life and the latter the sexual life of the plasmodium

The three species of malarial parasites the *Plasmodium vivax*, *Plasmodium malariae* and *Plasmodium falciparum* produce three distinct types of fever These are the Benign tertian Quartan and Malignant fevers The sexual forms of the Quartan and Benign tertian—that is to say those adapted for life and development in the mosquito—are spherical This form of Malignant tertian is crescentic There are male and female spherical forms and male and female crescentic forms The male sexual forms fertilize the female forms in the stomach of the mosquito and a cyst is produced which imbeds itself in the wall of the stomach Many such cysts are formed there and these appear in the walls of the stomach like raisins in a pudding The contents of the cysts divide and form spores or young parasites which find their way to the salivary glands of the mosquito This whole process which constitute the sexual life of the parasite in the mosquito takes about twelve days to complete Now the mosquito is ready to infect the other host Suppose she bites then down the proboscis or mouth parts travel these spores in the saliva of the mosquito and become injected into the man's blood stream The spores then attach themselves each to a red blood corpuscle enter and proceed

forthwith to destroy it by feeding on it The question of male and female forms does not here arise as we are now dealing with the asexual life of the plasmodium The plasmodium becomes bigger and bigger inside the red blood corpuscle until the time comes for it to divide The division goes on until instead of one parasite in the cell we get many which form clumps of spores known as rosettes *This is now the full ripe stage of the* parasite The red cell bursts and all these tiny spores are thrown free into the blood stream only again to enter fresh red cells and there begin once more the non sexual cycle Now this cycle takes time to complete In some cases seventy two hours are required Then the fever is called Quartan in other cases forty eight hours suffice for the completion of the cycle and then the disease is called Tertian and again the cycle may take place in under forty eight hours as is the case in Malignant or Sub tertian fever It is these forms that cause the symptoms of the disease The main symptom is fever which occurs when the rosettes burst and the parasites are thrown into the blood stream Therefore the fever will recur every third day with Quartan malaria and every second day or every day in the Tertian fevers

In process of time certain of the non sexual elements of the plasmodium become differentiat

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ed and form themselves while in the red corpuscles of the blood into spherical shapes called spheres and into crescentic shapes There are male and female spheres and male and female crescents according as the type is Quartan or Benign tertian in the former case or Malignant tertian in the latter case These forms do not cause any symptoms of fever and their sole function is to await the arrival of a certain mosquito which sucks them up into her stomach when she bites the individual and there they commence once again the sexual cycle as has already been described

It is in this manner that the complete cycle which causes the disease known as malaria carries on between the mosquito and man With this knowledge gained it remains for us to discover in what way we can endeavour to eradicate this disease We could for example turn our attention to the individual and by giving appropriate drugs kill out the plasmodium in his blood Unfortunately we have no known drugs on which we can depend for this ideal method of dealing with the disease Quinine which is excellent for controlling the disease has no action on the sexual forms in the blood We are therefore forced to look to the other host and find out if it can be dealt with in such a way that we can break the link in the chain necessary for the development of the plasmodium

Where there are no mosquitoes there is no malaria Hence if malaria exists in a locality and you want to free that locality of malaria you must free it of mosquitoes Thus our attention is directed to that enemy of mankind the mosquito which must be dealt with rigorously firmly and unscrupulously If one nation goes to war with another it strives to gain as complete a knowledge as it can of that other nation and of the armies of that nation in order that it may supply sufficient fighting forces to overcome them And so it is with the mosquitoes If we are going to eradicate and exterminate the mosquito we must get to know which mosquitoes carry the disease what their habits and environments are what is the life history of these mosquitoes and at what stage in the life history are they most easily attacked

Other diseases have also been traced to these pests two of which are very important namely yellow fever and filariasis while the common fever called dengue is also known to be spread by mosquitoes

CHAPTER II

THE LIFE HISTORY OF MOSQUITOES EGG LARVA AND PUPA

BEFORE commencing the study of mosquitoes it is as well that we should have some knowledge of how these creatures are classified in the animal kingdom and by what means we can distinguish them from other animals At the same time we can acquire a rough working knowledge of how mosquitoes are divided up into their several families tribes groups and so on

The mosquito belongs to the class of animals called INSECTA which are distinguished from all others by certain well defined characteristics Within this class certain groups of animals show common features Each of these groups is called an ORDER Mosquitoes belong to the order DIPTERA (flies) and their particular peculiarities are that they have one pair of membranous wings that their mouth parts are so constructed as to enable them to suck and that during their existence they pass from an egg to a larval then to a pupal and then to an adult stage or in other words exhibit complete metamorphosis

Again the order of Diptera is divided up into a large number of FAMILIES according to dissimilarities between certain of the creatures forming the order The family that includes all mosquitoes is called the *Culicidae* and it is characterized by its members all having long slender antennæ consisting of never less than six portions or segments having a definite arrangement of the veins on the wings and carrying scales on their wings This family is too large to treat as a whole so it has to be divided up into lesser families called sub families One sub family has long mouth parts often nearly as long as the body They bite and the veins on their wings carry scales This sub family is called the *Culicinae* and in it are included all the mosquitoes with which we have to deal

The *Culicinae* are divided into four TRIBES—the *Culicini* the *Anophelini* the *Megalorhini* and the *Sabethini* The *Megalorhini* or Elephant mosquitoes are large insects with long tapering mouth parts bent downwards and backwards like a hook and the *Sabethini* are forest living mosquitoes which are regarded as harmless to man but the *Anophelini* include all those which carry malaria and the *Culicini* all those which carry filariasis yellow fever, and dengue

The last two tribes are once again divided up into GENERA The *Anophelini* have only one

genus *Anopheles* while the *Culicini* have at least two—the *Culex* and *Aedes* The latter is usually spoken of as the genus *Stegomyia*

Very fine characteristics common to groups within the genera finally cause them to be separated up into different species These characteristics are always constant in the members of the same species Take for example the genus *Anopheles* There are some hundred and twenty different species recognized In the same fashion there are numerous species of the genera *Culex* and *Stegomyia* and among them attention must be paid to the *Culex fatigans* which spreads the infection of filariasis and dengue fever and to the *Stegomyia fasciata* which transmits yellow fever

With regard to the naming of a mosquito there are certain principles laid down First of all the name must be in Latin and if the words used are not Latin they must be latinized Secondly there are always two parts to the name of a mosquito the name of the genus followed by the name of the species Thirdly all names must be written in italics and the name of the genus begins with a capital while the name of the species commences with a small letter It is in this way that the names of the mosquitoes *Anopheles stephensi* and the *Culex fatigans* are arrived at These are usually written shortly thus— *A stephensi* and *C fatigans*



FIG 1



FIG 2



FIG 3

FIG 4



FIG 5

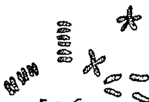


FIG 6

THE OVUM OR EGG

FIG 1 Culex egg raft (natural size)
FIG 2 Culex egg raft (magnified)
FIG 3 Lateral view of FIG 2
FIG 4 Anopheles eggs (natural size)
FIG 5 Anopheles egg (magnified)
FIG 6 Patterns formed by Anopheles eggs

differ in shape and position in different species of *Anophelini* and it is possible to some extent to distinguish between the eggs of some species of *Anophelini* by such characteristics The egg or ovum stage usually lasts from two to four days but may be a little less or a little more in different species and at different temperatures and then they hatch out into small wriggling animals called Larvæ

The Larva —The larvæ of mosquitoes are well known objects They consist of a head thorax or chest and an abdomen The characters of the abdomen are very important in that they give the readiest means of distinguishing between the main groups The abdomen consists of nine segments The first seven segments are very much alike The eighth segment carries the external openings (stigmata) of the respiratory tubes which serve to supply oxygen to the tissues of the larva In all *Anophelini* the larval respiratory tubes open directly upon the upper surface of the eighth segment The respiratory tubes of the larva of the genera *Culex* and *Stegomyia* do not open directly upon the eighth segment but are prolonged from it into a projection which is known as the syphon tube The absence of a syphon tube is characteristic of the larvæ of the *Anophelini* The length and character of the syphon tube is of impor



FIG 1



FIG 2



FIG 3

FIG 4



FIG 5

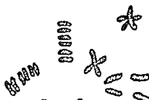


FIG 6

THE OVUM OR EGG

Fi 1 Cul x egg ft (tural si e)

Fi 2 Cul x egg raft (magnified)

Fig 3 L t al vi w of F g

Fig 4 Anoph le ggs (t ral size)

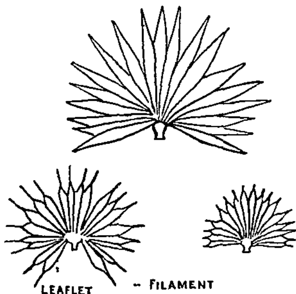
Fig 5 A oph l s gg (magnified)

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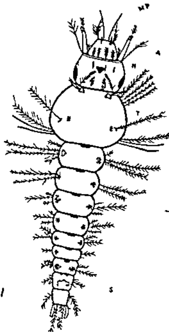
tance in distinguishing between the larvæ of the genera *Culex* and *Stegomyia*, it is short and thick in the larvæ of the genus *Stegomyia* while it is long and thin in those of the genus *Culex* The

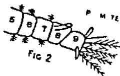


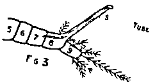
PALMATE HAIRS

N t the re embl t th l af of a ocoa t p lm t th l flets d th t rmi t l to fil m t whi h v ri l diff re t pecl but is th s m in th m p s

ninth abdominal segment carries the anal opening around which is arranged four large papillæ called the anal papillæ which are well supplied with air tubes and long curved hairs The most important appendages of the abdomen of anopheline larvæ







THE LARVA

1 (l pp P p lm t h l f A ph ll l p rt AB bdom H h d A

2 T ll of A ph ll l rva h t g AP lp p ll Γ th ra p se of p lm t h lts g bd ml l S gm t 5 t 9 Mi mou h ompare it with t figu e d th b of yph t be n S gm t 8 nd N i th b t the l c l x l rv f p lm te h lrs d pre f ph tub S gm t 8

heads and transparent bodies They change their position at the surface of the water by jerking or darting movements and when floating in the water they take up a horizontal position They possess palmate hairs and the respiratory tubes open directly on the surface of the eighth abdominal segment and consequently they have no syphon tube The antennæ terminate in two leaf shaped bodies between which a branched hair arises In most species of *Anophelini* a single unbranched hair arises at the junction of the proximal and middle thirds of the antennæ

Larvae of the Genus *Culex* —These larvæ form an angle with the surface film of the water and assume a hanging attitude The degree of this angle varies in different species for instance the *Culex concolor* assumes a very acute angle and lies nearly parallel to the surface film These larvæ have a long thin syphon tube but have no palmate hairs They have a large branched hair projecting from the side of the antennæ

Larvae of the Genus *Stegomyia* —These larvæ are long and worm like and have a wrig gling mode of progression through the water Their syphon tube is short and thick and when hanging from the surface film of water they assume an almost vertical position They have no pal mate hairs Compared with the rest of the body the head is small and it is not easy to say where the

thorax ends and the abdomen begins They have short inconspicuous hairs sometimes as many as three projecting from the sides of the antennæ

The larval stage usually lasts from eight to twelve days in the tropics and this is determined by at least two factors viz temperature and food In colder climates it lasts much longer Larvæ living under natural conditions in collections of water grow much more quickly than those kept in the laboratory in dishes of tap water

Larvæ are free swimming animals eat voraciously and grow rapidly During the process of their growth they cast their skins several times until they reach their final development At this stage they become much quieter and are very easily killed by merely agitating the water in which they are found The change from the larval to the pupal stage is sudden With a few rapid motions the larval skin is cast off and the worm like larva assumes a characteristic comma shape and becomes the pupa or nympha (see Diagram)

Certain larvæ of other insects may be mistaken for mosquito larvæ because they bear a superficial resemblance to them There are for instance larvæ of certain flies called Chironomus Ephemera Dixa and Corethra They can however be easily distinguished from mosquito larvæ by certain peculiar characteristics of their own

Chironomus larvæ are commonly known as

blood worms They are bright red worm like creatures *often found in large numbers* when the mud at the bottom of a small pool is stirred up In general appearance they bear no resemblance to mosquito larvæ

Ephemera larvæ may at first glance be mis *taken for mosquito larvæ but there is no real* likeness Their air tubes do not open externally and they obtain the necessary oxygen from the water by means of gills the presence of which renders them easily recognizable Also the tail *end of Ephemera larvæ terminates in a tri radiate* manner which marks them off distinctly from mosquito larvæ These Ephemeridæ are com monly known as May flies

Dixa larvæ rather closely resemble *Anophelini though not other mosquito larvæ* They move along the surface of water like Anopheline larvæ and they also rest horizontally just beneath the surface film But in Dixa there is no globular thorax all the segments are almost equal in size and the whole larva is longer and thinner than the mosquito larvæ They have no palmate hairs possess four legs by which they climb up the sides of the vessel in which they are kept and are in the habit of resting in a loop with the head and tail downwards These characters should prevent any difficulty in distinguishing these from Anopheline larvæ

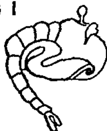
Corethra larvae are very transparent and are for this reason known as Phantom larvae They have *an exceedingly small* head and possess no respiratory syphon There is a swimming fan on the last segment and they lie horizontally *rather deep in the water*

The Pupa or Nymph —The pupae of mosquitoes are characteristic creatures comma shaped *in appearance* with a large globular body and a small tail The globular body includes the head and thorax The tail includes the abdominal segments When disturbed they dart downwards with great speed but soon reappear on the surface They sink in the water by making violent exertions with the tail and once the movements of the tail cease the buoyant pupa floats up to the surface Just before the hatching of the mosquito the pupa becomes less inclined for active movement and the tail may be extended horizontally Then a crack appears in the chitin[1] of the back of the thorax and the adult insect emerges through this crack and sits for a while on the empty pupa case drying its wings and then flies away as the full blown mosquito

In order to differentiate between the genera *Anopheles Culex* and *Stegomyia* in the pupal stage great attention must be paid to the differ

[1] Chitin a hard impermeable substance forming the covering membrane

ence between the syphons of these genera In the genus *Anopheles* they are stumpy and proportionately much shorter than in the genus *Culex* They have a square truncated end, and











THE PLPA

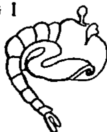
F G 1 Pupa of *A ph l* FIG 3 yphon t be f *A ph l*
FIG 2 Pup of Cul F G 4 Syphon tube of C le
F G 5 Sypho tube f St g my a.

project from the middle of the thorax while in the *Culex* the syphons are long and slender have an oblique opening and project from the posterior portion of the thorax In the genus

Stegomyia on the other hand the syphons are triangular and broad and hence are very characteristic The pupæ of the *Anophelinæ* lie less vertically in the water and are longer and narrower than those of the genera *Culex* or *Stegomyia*

In the tropics the nymphal stage lasts about forty eight hours

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THE PUPA

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FIG 2 Pupa of C l FIG 4 Sypho t be of C l
FIG 5 Syph n t be of Stegomyia

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CHAPTER III

THE ADULT MOSQUITO OR IMAGO

THE *Imago is the winged insect well known* to those living in the tropics As in all other insects the body of a mosquito consists of three distinct regions—the head the thorax and abdomen

The Head carries the sensory and suctorial organs It is more or less globular in shape and is attached to the thorax by a narrow neck The upper surface of the head is mainly occupied by *the two large compound eyes The portion of* the head which lies between the eyes is called the vertex while the frons is that part which lies in front of the vertex Immediately behind the eyes lies the occiput while the nape is the portion behind the occiput at the extreme back of the head The prolongation of the frons anteriorly is spoken of as the clypeus Immediately in front of the eyes on either side arise the antennæ These are long jointed structures provided with hairs and consist of fourteen to sixteen segments Beneath the clypeus arises the proboscis The proboscis is a collective term given to the highly specialised mouth parts which consist of the upper

See *Frontispiece*

lip the lower lip the tongue two mandibles two maxillæ and two maxillary palpi The lower lip or labium is a grooved structure enclosing the other mouth parts and forms the thick scaly proboscis as usually seen The two maxillary palpi lie on either side of the proboscis and are of generic and specific importance Each palp consists of four segments

The Thorax carries the locomotory appendages in the form of one pair of wings and three pairs of legs The anterior portion of the thorax is a collar like piece of chitin and is called the prothorax while the middle portion is called the mesothorax and forms the large globular mass of the thorax Behind the mesothorax a prominent ridge called the scutellum runs between the bases of the wings Behind the scutellum a horse shoe shaped area called the post scutellum can be readily distinguished The scutellum and post scutellum are of importance in the classification of mosquitoes

The wings of mosquitoes are long with an anterior straight border called the Costa which in *Anophelini* is usually covered with white and black scales forming the spotted margin There is also a posterior curved border fringed with long scales forming the wing fringe In *Anophelini* this has also light and dark portions the extent and position of which are made use of in the

tinguished from the female by observing with the aid of a hand lens that, *whereas the male antennæ* are markedly feathery or plumose, the female have only short lateral hairs and whereas the male palpi are long and hairy the female are much less conspicuous Another difference lies *in the fact that the female feeds on blood whereas* the male prefers to suck vegetable juices

There are some members of the order Diptera (flies) which may be mistaken for mosquitoes Mention will be made of the chief ones which *can be distinguished by noting a few charac* teristics of each First there are the *Chiro nomides* (Midges) which do not possess the characteristic proboscis of mosquitoes Their legs are long and slender and the veins of their wings *do not have scales Then there are the Tipulidæ* (Daddy long legs) which have no distinct pro boscis and possess long slender legs the *Simulidæ* (sand flies) which are tiny insects with a short stout proboscis and lastly *Rhyphus fenestralis* a fly often seen on windows which may be mistaken for *Anophelini* as its wings are spotted but there are no scales on the wings and the second longitudinal vein is not forked

In the identification of mosquitoes it is neces sary in the first instance to observe whether the insect under consideration belongs to the order Diptera (flies) This is determined by observing

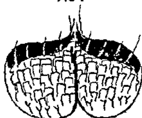
whether the mouth parts are constructed for biting or sucking and whether they have one pair of membranous wings. Once it is decided that the specimen belongs to that order the possession of scales on the wings and body and the characteristic wing venation will place it in the family *Culicidæ*, while the sub family *Culicinæ* will be chosen if the specimen carries scales on the veins of the wings and if the mouth parts are made for biting. If the specimen is a *Culicinæ* it is necessary still further to determine its correct tribe, whether it be *Anophelini* or *Culicini*. It will be sufficient for our purpose if we observe the distinguishing features between these two tribes, it being understood that should the specimen not fulfil these conditions it probably comes under the heading of some other tribe.

It is essential in distinguishing the *Anophelini* from the *Culicini* to observe the wings. As a rule those of the former are spotted while the latter are not. These spots are caused by areas of white and dark scales on the veins and always occur with *Anophelini* except in certain species, three of which are found in India and must be carefully noted. They are *A. aitkeni*, *A. barianensis* and *A. culiciformis*. Whereas nearly all the species of the *Culicini* have uniform dark wings the *C. mimeticus* has costal spots. As a rough guide this differentiation is exceedingly valuable. Again

the proboscis of the *Anophelini* continues in a straight line with the body while in the *Culicini* it forms a distinct angle This accounts for that characteristic attitude adopted by these tribes when resting on the wall The body of the resting *Anophelini* forms a distinct angle with the wall whereas the *Culicini* appear either parallel to it or have a hunchbacked appearance There is however an exception as the *A culicifacies* a common mosquito in India holds its body horizontally as do members of the *Culicini* Again the palpi are long in both the male and female *Anophelini* whereas they are long in the male but very short in the female *Culicini* The most accurate and scientific distinction between these two tribes lies in the fact that the scutellum of the *Culicini* is trilobed whereas the scutellum of the *Anophelini* is simple and never trilobed This observation however is not easy to make with any degree of accuracy with a hand lens and requires repeated and constant practice to become expert but with a microscope this difference can readily be seen

As there is only one universally recognized genus of the tribe *Anophelini* once a mosquito is placed in that tribe it naturally becomes classed in the genus *Anopheles* There are however at least two genera of the *Culicini* the genus *Culex* and the genus *Stegomyia* (*Aedes*) which must be distinguished

Mosquitoes of the genus *Stegomyia* are popularly known as tiger mosquitoes on account of the prominent alternating white and dark stripe like areas seen on the abdomen and legs of some species of this genus Unlike other mosquitoes they can be seen feeding during the day but





F I HEAD SCALES OF STEGOMYIA
... row cu d al Th y re ll fl t l with l w upright f ked

F HEAD SCALES OF CULEX
Fl t sc l s ry l w d ply t th id Th y re mostly row curved scales and som p ight forked

these features can by no means be relied upon as an accurate and scientific means of distinction Although these two mosquitoes are obviously distinct yet many mosquitoes which at first sight appear to be identical are often found to be quite different on examining their scales The head scales in the genera *Culex* and *Stegomyia* are quite different and are of importance in

the identification of these two genera (*vide* plate)

All mosquitoes of the genus *Culex* have on the head mostly narrow curved and upright forked scales but only a few flat scales laterally whereas all mosquitoes of the genus *Stegomyia* have on the head practically all flat scales with only a few upright forked and no narrow curved scales at all Further the clypeus in the genus *Stegomyia* is scaly while in the genus *Culex* it is hairy These differences can only be made out with the aid of a microscope

Having now determined the exact genus to which a mosquito belongs it is necessary to proceed to the final step of the identification of the species As so far only *Anophelini* have been incriminated in the transmission of malaria it will therefore only be necessary in this book to deal with that genus The most important distinguishing features are the following and one should get thoroughly acquainted with what they are and where to look for them so that deviations can be easily detected and the species therefore identified Each inspector should by practical experience make himself thoroughly familiar with the use of the hand lens before he can hope to become expert at distinguishing these minute characters

The Costal Spots —The spots on the wing

are caused by patches of white and dark scales on the costal vein the sub costal vein and vein 1 The costal spots are fairly constant in each species and the number and extent are of con siderable importance in the determination of species

The Palpal Bands —Here again patches of white scales occurring at the junction of the palpal segments give the appearance of white bands These are also fairly constant in each species The presence of such bands their number and extent are all made use of in the determination of species In *A barbirostris* for instance there are no white bands the whole palp being dark scaled In *A kochi* there are five white bands in *A hyrcanus* there are four white bands and in *A culicifacies* there are three white bands so that each individual species has invariably got definitely marked palpi

The Wing Fringe —At the points of junc tion of veins 1 to 6 with the costal vein which passes right round the wing sometimes light areas occur due to the presence of white scales Such light areas differ in different species but are fairly constant in the same species In *A culicifacies* for instance there are not more than two light areas on the wing fringe while in the *A listoni* there are six light areas

The Wing Veins —Here again the presence

of dark and white scales on the wing veins causes definite dark and light areas in the wing field which are fairly constant in the same species In *A culicifacies* for instance vein 3 is almost entirely dark except for a small white area at its commencement whereas in *A stephensi* the third vein is almost entirely white except for two small dark areas one near its commencement and the other near its termination

The Legs —Banding of the legs, like those of the palpi is also of specific importance It must be noted whether banding is present in each segment and if so whether it is apical basal or both whether any segments are completely white and so on In *A subpictus* for instance the front tarsal segments are distinctly and broadly banded In *A theobaldi* the last two hind tarsal segments are completely white, while in *A culicifacies* none of the tarsal segments is white

Speckling —This is a condition which in some species is present on the legs or on the palpi or on both When such a condition exists the palpi or legs look as if they are distinctly marked with white and dark spots the best way to get familiar with this condition is actually to look at a specimen with speckled legs or palpi and when once seen it cannot be mistaken *A stephensi* for instance, has speckling on the legs and palpi *A theobaldi* has only

speckled legs, while *A subpictus* has neither speckled legs nor palpi

All these conditions could invariably be made out by means of a hand lens (10 to 20 times magnification) and with a little practice the identification of species with the aid of a synoptic table is a simple procedure in the large majority of cases Such synoptic tables have been published by different authors and as an appendix will be found the synoptic table issued by the Central Malarial Bureau Kasauli 1926

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CHAPTER IV

THE HABITS OF MOSQUITOES

BEFORE entering any given district for the purpose of taking anti mosquito measures the squad with its inspector at its head will have been made acquainted with the types of mosquitoes that they are likely to encounter This gives the key to the solution of the problem which faces them as to where they are to look, not only to encounter mosquitoes but to discover where they are breeding This information is received from what is known as a survey of the district and is generally undertaken by expert entomologists and their trained assistants A catch is made of all mosquitoes that can be found in the district and also any larvæ discovered are carefully pre served These catches are made throughout a whole year and months which show a large increase in numbers are noted The mosquitoes are classified and preserved under their several names and large numbers are dissected to *discover in what proportion the various mosqui* toes carry malaria in nature As a result of this information a plan of campaign is put forward which will aim at the elimination of the breeding places of such mosquitoes for if mosquitoes are

not allowed to propagate they will be gradually eliminated

Armed then with a complete list of the various kinds of mosquitoes the inspector will be put well on the way to discover their whereabouts because experience has taught us many of the ways in which the various species live and propagate

It is common knowledge that marshes breed mosquitoes and operations on a large scale have been undertaken at great financial outlay to drain them but sometimes without any diminution in the amount of malaria in the surrounding country In some of these cases it was not until more careful observations had been made of the habits of the mosquitoes carrying malaria that the channels themselves built to drain the marshes were found to be the offenders as they harboured the larvæ of a mosquito which bred in running water Thus the object of the undertaking was not fulfilled through lack of a thorough knowledge of the habits of the various species of mosquitoes in that district

We approach the subject of the habits of mosquitoes first of all from a general aspect These insects whose persistent annoyance is the source of much incovenience and distraction to all who have lived in areas where they abound usually pester their victims in the night and one of two courses both very apt to prove a false

security is available as a protection during sleeping hours Either the individual must cover himself with a foul smelling oil which although repugnant to the none too refined tastes of the mosquito is much more repugnant to the unfortunate person trying to get a night s repose, or he must sleep under a mosquito net which will by the closeness of its meshes keep out the cool gentle night breezes so refreshing on a hot tropical night and much of the current of air caused by an electric fan Unless the utmost care is exercised that the net is properly used and kept in repair he will awake in the morning after a hot restless night to find sitting in one corner of the net two or three of these pests gorged with his own blood too sleepy to fly away from the consequences of the savage wrath they engender in the breast of their victims Far better it would be to sleep without a net in a bungalow not hampered by mosquito proofing and awake refreshed from a sleep in the open air in the cool breezes untroubled by the attacks of these winged pests

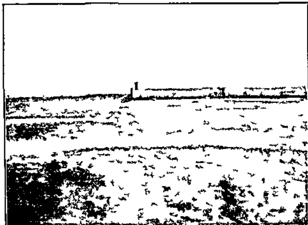
Generally speaking we divide the mosquitoes into two great bands We have those which inhabit the vicinity of houses stables cattle sheds, and so on They live and breed in and around them and their life is lived in a very circumscribed area These we may call 'House

hold mosquitoes Then we have those which live in the surrounding marshes rivers and streams and fly to houses for protection from the heat of the day and for the purpose of sucking the blood of mammalia—these we may call Country mosquitoes Although it is not arbitrary these two classes may roughly be said to include in the former the *Culicini* and a few *Anophelini* and in the latter most of the *Anophelini* and some *Culicini*

Again it is not all mosquitoes which will bite human beings—only the females The female will feed upon mammalia after she has become fecundated as it is generally understood that blood is necessary to her for the true development of her ova It is generally accepted that males never suck blood The adult male remains more or less in the vicinity of the breeding place and meets his mate after she has hatched from the pupal stage or has arrived and laid her eggs Mosquitoes as a rule have many sources of food supply Fruit and vegetables of various kinds especially if they be over ripe and mammalian blood are their usual diet The female will not select a spot for laying her eggs where there will be no food for her offspring Thus dirty water gully traps and cesspools are popular breeding places of the *Culicini* while clean water marsh or ponds with vegetation are frequented by the

Anophelini Of course, when driven to it they may deposit their eggs and larvæ may hatch out in water where no suitable food appears to be but for preference the other more suitable sites are selected

During the heat of the day mosquitoes will seek out sheltered spots to escape from the sun which they do not like Thus they are found reposing in the shade amongst long grass or under the leaves of trees and it is this phenomenon which has given rise to the erroneous impression that long grass and undergrowth necessarily breed mosquitoes and drastic operations have been undertaken to rid occupied areas of them often rendering pleasant and beautiful districts desolate Mosquitoes breed in receptacles concealed in grass and undergrowth and in the hollows of trees where water can accumulate after rain If these are properly dealt with as will be mentioned later, it will be unnecessary to spoil beautiful gardens and remove the benefits of shade by the destruction of trees During the day mosquitoes may also be discovered hiding in houses from the heat and sun especially in dark corners cupboards presses and among clothes hanging up They are not generally found in the vicinity of cooking ranges, but *Anophelini* have often been found reposing on cobwebs looking like tiny little bits of dirt hanging downwards



THE SEA HORE AT COLABA BOMBAY

A f t bre d g p t f th *4 t pher* Th ll t tl h w th f t b i g fill d p w i h m d f m d dg tw m l w y



MARINE GROWTH

A f t b l g gr d for *A ph l*

As evening approaches and the day cools they come out of their hiding places and feed and in most species the female then seeks out warm blooded animals After having fed on them and being ready to lay her eggs she proceeds to the breeding water and lays them on its surface There she finds the male awaiting her and once more she mates with him and the whole process is repeated It must always be remembered that if a number of male mosquitoes are discovered in any one locality it is an indication that there are mosquitoes breeding nearby Having grasped these few points we will now pass on to consider the haunts of the various genera of mosquitoes

The *Culicini* select breeding places which provide food for their young For this purpose cesspools gully traps and collections of dirty water in and around houses stables and cow sheds are their favourite haunts and here they are also near their mammalian food supplies Except for the genus *Stegomyia* which are day feeders they mostly feed at night During the day they hide themselves in cool corners cup boards amongst clothing and so on in order that they may escape the heat and glare of the tropical sun As evening approaches they come out to feed and they become annoying till dawn when once more they seek shelter from the oncoming heat The adults are most easily caught during

the daytime if diligent search be made for their places of concealment They are seen sitting patiently in their typical positions and a glass tube can be gently and slowly passed over them In the evening they fly about and are not so easily caught but with nets they may be captured after a little practice Their larvæ can be discovered in wells gully traps open drains cess pools tanks and old tins which have been left lying about Old barrels motor tyres cigarette tins and bottles will all hold water in the rainy season and are favourite sites for ovipositing with many of the mosquitoes In the compound should you find trees they should be searched *carefully with a view to discovering whether there* be any holes which retain rain water

Long grass and rank vegetation in themselves do not breed mosquitoes but they are splendid positions for mosquitoes to take up during the heat of the day and they harbour all sorts of tins bottles and rubbish which catch rain and afford excel lent cool water in quiet spots for breeding Thus it will be found that when search for mosquitoes in and about a house has proved unsuccessful and just as you are about to abandon *all* hope of discovering any breeding places, your attention is arrested by that corner of the compound which in many households seems to be a sort of dumping ground for odds and ends And there amongst

the grass is an old rusted tin with its broo larvæ and pupæ Nor do even the most i cent looking bamboo poles used as supports sheds and lean to buildings escape The fe bamboo is a hollow structure and should ther any cracks or holes in it rain water will co and breeding will certainly result

Within the house itself the careful inspe will generally find certain spots which are h places for breeding mosquitoes Among t the water cistern which has not been rend mosquito proof and the waterseals of wash d water closets which are not in daily use ma mentioned Flower vases and anti formicas or holding water which are placed under the le tables to prevent ants from swarming up food placed on them have very often been covered to harbour larvæ The utmost must be taken by the inspector to trace ou possible vessels containing water These must strive to have emptied daily and an them are the earthenware vessels called *cha* which are in common use in India

If one were to turn one s attention to multiplicity of breeding places that can dail discovered in cities especially in factories yards volumes could be filled dealing with inspector s work Suffice it to say that on principles evolved in this chapter the intelli

searcher will soon discover all the important breeding places provided he has the co-operation of those living and employed in any establishment he may visit

The *Anophelini* are usually found breeding in the country although certain species e g *A stephensi* and *A subpictus* are frequently to be discovered breeding in water cisterns and especially in wells in houses and compounds But generally speaking the *Anophelini* for example *A maculatus* and *A theobaldi*, live in marshes, river beds and jungle pools The female flies to the habitations of man and his domestic animals to feed upon blood and thus during the day she *may be found freely in infested houses in just those* places where the *Culicini* are found As a rule they attack their victims at night, but here again we may come across exceptions as certain species bite during the day while others appear to reserve their energies until the early morning Having fed upon blood she then flies back to her jungle pool marsh river bed or seashore and there lays her eggs and once again in the vicinity she finds the male awaiting to mate with her and the whole process is repeated

People often ask how far a mosquito can fly With a wind behind them they can certainly travel great distances, but against a wind their range is naturally more limited But

some maintain that if the wind be not too strong distance of flight is affected very little Generally speaking *Anophelini* live within a radius of one mile from their human food The adults in flying from their breeding beds occasionally show most erratic habits They will for example find their way not to the first house in a village but to the last missing out houses in a curious manner Adults are very conservative about their breeding haunts and return to them time and time again Most species show the extraordinary habit of keeping to the same type of breeding place Certain species for example breed in the shady pools of jungles and will not breed anywhere else Again other species breed in the running water of streams and will not breed in still shady pools It is now very generally accepted that the different species will not alter their methods of breeding and once the places have been eliminated the species dies out They do not appear to be able to carry on as that species unless the conditions of breeding common to the species obtain Thus it comes about that the inspector who knows the mosquitoes which are breeding in his district will also know where to look to find their breeding haunts

It has often been stated that mosquitoes do not breed to any extent in sea water This is not our experience in Bombay where the *A stephensi*

A subpictus A culicifacies and *A agus* have all been discovered breeding in salt water on the sea shore On one occasion the water was three times as salt as sea water However there are strict limitations to their breeding on beaches We have always found them in pools among rocks on that strip of the beach which lies between the high water mark of spring tides and the high water mark of neap tides The presence of mangrove and other vegetation increases the likelihood of breeding in such areas Mosquitoes have not been found breeding in the open sea or on that part of the seashore where the daily rise and fall of the tide take place

The breeding places of mosquitoes can be divided into two great classes permanent and temporary Bentley in his work on malaria in Bombay has demonstrated that the chief carrier of malaria in that city is the *A stephensi* This mosquito is known to breed all the year round in wells water cisterns and pools on the seashore They are usually found in small numbers in these sites and it is thought that their natural enemies prevent them from becoming too numerous When the monsoon breaks, rainwater pools and a variety of collections of water become abundant throughout the city and the mosquitoes spread from their permanent breeding places to these temporary ones, and this results in the appearance

of multitudes of mosquitoes capable of carrying malaria. Within a short time malaria rages in the city. When the monsoon ceases and the temporary breeding places dry up and exist no longer then the mosquitoes return to their permanent breeding sites and consequently the incidence of malaria drops. Our experience in Colaba confirms these observations. Permanent places where breeding occurs are those positions in which water can be found throughout the year. They include wells, water cisterns, garden tanks, pools in river beds, streams, water channels and so forth. Temporary breeding places are such as occur during rains and include collections of water in storm water drains, sheets of water on the ground and the numerous sites about a household already enumerated. We give at the end of this chapter a list of Indian *Anophelini* and it is recommended to the careful study of every inspector. However there is another way in which mosquitoes will remain alive when conditions are not favourable for their propagation. Should the weather be too hot or too cold to favour their continued existence then adult females which are about to lay their eggs seek out some quiet cool spot and there settle down and pass into a torpid state in which they seldom if at all feed and appear to be asleep. If this occurs during cold months it is spoken of

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as 'hibernation A similar condition may occur in hot dry months in the tropics and then the mosquitoes are said to 'aestivate

The manner in which mosquitoes become distributed over a given area is interesting They may be and are blown to considerable distances from their breeding haunts by strong winds and being unable to return they are perforce obliged to seek out fresh collections of water in the neighbourhood and though it is usual for mosquitoes to return to the vicinity where breeding abounds yet it is not always so Some may arrive at fresh water collections which have a plentiful supply of food for larvae especially those to the leeward of the habitations to which the adult flies for its mammalian food Again irrigation channels can carry larvæ a long distance and those surviving start new foci further down the channel

The age to which an adult mosquito may live has not been worked out for each species The males are much shorter lived than the females The life of a female may be put at anywhere between six weeks in certain species to three months in others

TABLI OF *ANOPHLLINI* (INDIA) SHOWING DISTRIBUTION AND BREEDING HABITS

NAME OF SPECIES	DISTRIBUTION	BREEDING HABITS	REMARKS
A. ... ilte n—James	Kar var Fronti r of Lov Bengal Duars And mans Burma Ass am S Indi	Breeds in ingle pools	Rests like *Culici n* I eeds in sha le d iring the day
A. ... br stris—Van d r W lp	Thr ughout India and the Andaman I land	Breec in hally pools in jungles orchards and gardens	Not commonly found in houses
A. ... culicifa ies—Gil s	W dely li tributed thr igh ut India	Pools of rain water paddy field and pool n dry ri r bed Breeds in well or any collection f water including brackish water	Carries the parasites f m laria in Natur The *Imago* has an attitu le on resting milar to *Culicini*
5 *A. ... ... mus*—Cogill	Bombay Karwa South India	Breeds in h les of trees	A lult rests like *Culicini*

TABLE OF *ANOPHELINI* (INDIA) SHOWING DISTRIBUTION AND BREEDING HABITS—(*Contd*)

NAME OF SPECIES	DISTRIBUTION	BREEDING HABITS	REMARKS
A fuliginosus—Giles	Throughout the whole of India and Burma up to 3 000 feet	Pools ponds and tanks with vegetation at sides A swamp breeder	Carries the parasites of malaria in nature Found more especially in cattle sheds
A gigas—Giles	A hill species found in the Nilgiri Hills and hills of Southern India also Himalayas	Breeds in pond and the dew ponds of Simla Hills	A wild mosquito but rarely seen in houses
A hyrcanus—Pallas	Bengal Punjab Bombay and Madras Presidencies	Breeds in swamps and water with much vegetation and in rice fields	Carries parasites of malaria in nature Feeds mostly by day and not often found in houses
A jamesii—Theobald	Bengal Central Provinces and parts of South India Madras City		
A jeyporiensis—James	Jeypore Agency Central Provinces and parts of Southern India	Breeds in streams irrigation channel of rice fields	

A. karwari—James	Bombay Presidency, Central India and Assam		Has been infected with the parasites of malaria in laboratory
A. kochi—Dönitz	Assam	Fresh water pools	
A. leucosphyrus—Dönitz	Burma, Assam, Bombay, South India	Breeds beside forest streams	Forest species found abundantly in coolie huts. Suspected to carry parasites of malaria
A. lindesayi—Giles	Himalayas and hills of Southern India	Breeds in streams in hills	Hill species
A. listoni—Liston	Berars, Central Provinces, Bengal, Duars, Jeypore Agency, G. Bombay, Hyderabad Deccan, North Canara District, Ceylon, Assam	Notorious stream breeder	Carries parasites of malaria
A. ludlowi—Theobald	Bengal, Burma, Andamans	Chiefly a salt water breeder found not far from sea-shore	Carries parasites of malaria

TABLE OF *ANOPHELINI* (INDIA) SHOWING DISTRIBUTION AND BREEDING HABITS—(*Contd.*)

NAME OF SPECIES	DISTRIBUTION	BREEDING HABITS	REMARKS
A. maculatus—Theobald	Bengal Duars North west Himalayas South India	Breeds in streams	Carries parasites of malaria
A. maculipalpis—Giles	General throughout India	Pools which may be connected with hill streams	Carries the parasites of malaria
A. minimus—Theobald	Assam Bengal Central India (rare)	Stream and pond breeder	Carries the parasites of malaria
A. palliaus—Theobald	Central Provinces	Rice fields borrow pits but not flowing water	
A. plumbeus var. *[illegible]anensis*—James	Western Himalayas above 6 000 ft	In the hollows of trees	During day found in hollows of trees Enters houses morning and night to feed

A pulcherri s—Theob ll	No th West F nt r I nj b specially the west Un ted I rovinces Bombay Presidency	In hallc v po l e k ra uwater pools	
A r/o tesiensis—Th b ll	*Balu hi tan Quetta* Kohat	Similar to *A c lici fcies*	
A stephe isi—L ton	Thro ghout India	Notorious well breeder Als any collecti ns of fresh a er br eds freely in sea water	Notorio carrier of the parasites of malaria
1 *superpict s*—Grassi	North West F nti r chiefly Q etta	Br eds in pools in stream beds	C rries the p r s tes of mal ria
A subpictus—Crassi	Throughout Ind	Shallow po l paddy fi ld temp rary pools domesti p ts m y breed in lt water	May rry parasites of n laria but i n t th ught to aff ct m i h th nciden of th di ase
A tesselatus—Th ob ll	Rare in India but may be f und in Assam C n tral and So th Ind a West Coast Burma	Suga cane brakes	

TABLE OF *ANOPHELINI* (INDIA) SHOWING DISTRIBUTION AND BREEDING HABITS—(*Contd.*)

NAME OF SPECIES	DISTRIBUTION	BREEDING HABITS	REMARKS
A. theobaldi—Giles	West Coast and Central India	Swamps and margins of lakes and streams	
A. turkhudi—Liston	Berars, Central Provinces, Kashmir, Punjab, North West Frontier	Breeds in clear pools and pools in sandy river beds	Larvæ rests like *Culex* at surface of water. Carries parasites of malaria
A. vagus—Donitz	Burma, Assam, Bengal, Bombay	Clean fresh water and brackish pools on sea shore	
A. willmori—James	Foothills of Himalayas up to 6,000 ft. from east to west	Breeds in streams and clear pool	Carries parasites of malaria

CHAPTER V

PREVENTIVE WORK

BEFORE describing in detail any measures on a large scale which may be undertaken to eliminate as far as possible the mosquito pest let us consider for a moment the main criticisms with which the advocates of an anti mosquito scheme are sure to be faced Several aspects of the question are bound to be brought forward for criticism and it is well that all who are more educated in these matters should have a ready answer One of the first comments will be that it is a quite hopeless task to exterminate all mosquitoes and therefore it is a waste of time and money to attempt it It is difficult to convince the uneducated of the futility of taking up such a position When the armies in France in the Great War were worried beyond measure by lice and fleas it was not proposed to kill all the lice and fleas to free them of their troubles Life was made well nigh impossible for such parasites as require man as their host by the free use of insecticides frequent bathing daily change of clothing where possible and disinfestation at properly prepared stations And so it is with

mosquitoes We do not advise extermination out of hand but a prolonged campaign based on a sound knowledge of the life and habits of certain tribes of mosquitoes well known to be inimicable to the health and comfort of man

Another criticism but one much more difficult to dispose of is whether the large and oft times vast expenditure which will be incurred by public communities and private concerns in the launching and future maintenance of an anti mosquito campaign is worth while This is too large a subject to be dealt with in this small book but in all cases the pros and cons must be carefully weighed and from this point of view all schemes put forward should be as economical as possible and should be adjusted so as not to overlap the work of other departments in a community—for example the work of the Sanitary Department The saving to a community of hours of labour and many valuable lives besides the reduction of expenses in hospital maintenance should be reckoned as valuable assets In this connection one should be conversant with the work on *The Prevention of Malaria in the Federated Malay States* written by Sir Malcolm Watson Many laudable undertakings have ended in disaster through the neglect of anti mosquito measures The Panama Canal Scheme was attempted several times before a successful issue was achieved for this very

reason and loss of reputation vast sums of money and many human lives resulted from the neglect of not incurring an initial expenditure on anti mosquito work It was not until it was realized that due regard must be paid to the mosquito that large sums of money were forth coming to undertake a campaign and only then was it possible to see the completion of the Panama Canal

Within our limited experience we know of several important business concerns which have come to inglorious ends because their directors failed to realize the part that the mosquito played in the success or failure of a commercial enterprise In commercial houses established in India it is the custom to maintain their staffs on a basis of allowing annually for a very large percentage of sickness almost wholly malaria

As we have already explained the links in the malarial chain are the plasmodium the human reservoir and the *Anophelini* These three links are absolutely necessary for the chain of malarial infection If any of them be absent then malaria cannot exist, thus it follows that the lines of defence and offence should naturally be directed against the destruction of these links thus rendering the chain impossible All defensive measures will be based on the avoidance of human reservoirs and infected *Anophelini* while

offensive undertakings will be directed against the plasmodium in the infected individual and prosecuted with a view to the destruction and if possible extermination of the *Anophelini* concerned

Measures to Avoid the Human Reservoir —The system of cantonments in India where the troops are located away from the crowded quarters of the city is a very good example of the advantage accruing from this method The troops are thus frequently spared the risk of infection by *Anophelini* which have fed upon the human reservoir in the city and it is well known that the malarial incidence in a cantonment is distinctly lower than that of the adjoining city The moral that we learn from this is that in the location of new sites for human habitation factories mills labour lines and so on one should always take into consideration the state of endemic malaria in the adjoining places and then decide on a suitable spot All houses situated in mosquito infested areas should be rendered mosquito proof by means of wire gauze the mesh of which should never be larger than sixteen to the inch In hospitals and houses persons suffering from malarial fevers should be screened so as to prevent the *Anophelini* becoming infected and thus transmitting the disease to others in the ward or household

SEARCHING A POOL FOR LARVAE

SPRAYING POOLS WITH LARVACIDE

Measures to Kill the Plasmodium in the Blood of the Human Reservoir.—This virtually means treatment of infected persons by quinine which is the only drug we know that will act on the plasmodium. Unfortunately the success of this method depends on the regular and prolonged administration in suitable doses of a drug which unless very strict precautions are taken to avoid loopholes either in its preparation or administration is liable to be abused for quinine is an expensive drug and by no means an attractive medicine to swallow. Instances do exist however especially in Italy where this method of malarial control has been used with success.

Measures to Exterminate the *Anophelini*.—This method strikes at the root of the matter and will therefore constitute the ideal weapon in our hands. We can kill the enemy either in their stage of existence in water collections or when they are on the wing. It is obvious however that it is much easier to attack the mosquito in its aquatic period of existence than to hunt after it when it is flying. All living creatures have their enemies both natural and artificial and the study of these enemies may reveal a very efficient method of dealing with mosquitoes.

The Natural Enemies of Mosquitoes.—The adult mosquitoes can often be seen falling a prey to birds, bats, lizards, ants, etc. and certain

species of fish also attack and devour them when they approach sufficiently near the surface of water Though a number of mosquitoes can be destroyed in the adult state by such enemies it is probable that this loss is small compared to that caused by the natural enemies which attack the insect in its larval state Amongst such natural enemies fish take the first place Unfortunately all fish do not eat mosquito larvæ but only certain species Amongst the fresh water fish that eat them are the following *Anabas scandens*, *Haplochilus lineatus*, *Polyacanthus cupanus* *Barbus stigmata* a species of the genus *Ophiocephalus* and *Macrones* The sea water fish that are known to eat mosquito larvæ are the *Therapon jarbua* and a species of the genus *Mugil* It is probable that there may be several other species of fish which feed on them Should any collection of water be met with where fish are present and mosquito larvæ absent it is worth while testing whether the fish eat them Put some of these fish in a suitable glass vase and put some larvæ with them and watch the result As some fish do not eat the larvæ as soon as they see them, it is best to observe the experiment for twenty four hours Where there is much weed and floating vegetation in the water mosquito larvæ take cover under them and defy the fish The use of fish as larval eaters opens out

immense possibilities of successfully preventing breeding of mosquitoes in permanent collections of water especially where there is no vegetation There is no easier method of dealing with the pest

Certain aquatic insects such as water boatmen and some beetles and bugs also destroy mosquito larvæ Some plants such as that which is commonly known as the rootless duckweed are also said to be their natural enemies The successful use of these natural enemies is a matter of individual discretion on the part of the person carrying out mosquito destruction

The Artificial Enemies—The artificial enemies of mosquito larvæ are what are known as larvacides The most commonly used larvacide is oil which by blocking the respiratory passages of the larvæ suffocate them Kerosene crude oil castor oil and gingelly oil are some of the oils that are generally employed either alone or in different combinations The most commonly used combination is a mixture of equal parts of kerosene and crude oil A mixture of crude oil and crude carbolic acid (20 per cent) in equal parts has proved highly satisfactory in our experience Various disinfecting fluids such as Cresol Izal and Newcol are also highly larvacidal The employment of disinfectants as larvacides is dependent on the correct strength of dilution of the disinfectant An insufficient amount of disinfec

species of fish also attack and devour them when they approach sufficiently near the surface of water Though a number of mosquitoes can be destroyed in the adult state by such enemies it is probable that this loss is small compared to that caused by the natural enemies which attack the insect in its larval state Amongst such natural enemies fish take the first place Unfortunately all fish do not eat mosquito larvæ but only certain species Amongst the fresh water fish that eat them are the following *Anabas scandens Haplochilus lineatus*, *Polycanthus cupainus Barbus stigmata*, a species of the genus *Ophiscephalus*, and *Macrones* The sea water fish that are known to eat mosquito larvæ are the *Therapon jarbua* and a species of the genus *Mugil* It is probable that there may be several other species of fish which feed on them Should any collection of water be met with where fish are present and mosquito larvæ absent it is worth while testing whether the fish eat them Put some of these fish in a suitable glass vase and put some larvæ with them and watch the result As some fish do not eat the larvæ as soon as they see them it is best to observe the experiment for twenty four hours Where there is much weed and floating vegetation in the water mosquito larvæ take cover under them and defy the fish The use of fish as larval eaters opens out

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tant added to a collection of water will be far too dilute to be of any use as a larvacide Hence it is preferable to use a disinfecting fluid like Cresol or Izal in shallow collections of water, and oil in large collections where a continuous surface film will suffocate the larvæ and kill them Certain chemicals such as sulphate of iron and sulphate of copper also destroy mosquito larvæ when added in proper strength to the water in which they are breeding but by far the best chemical we have come across is a substance called Paris Green This is an arsenical compound and is diluted in one part in 100 parts of fine cork or road dust and strewn over the surface of water where larvæ are to be found This can be usefully employed in large collections of impounded water such as tanks and ponds where the use of oil or any other larvacide will be far too expensive to be practicable

In order to be able to detect breeding in collections of water every inspector should by practical personal experience be thoroughly conversant with the methods described below Mere book knowledge in this very important section of his work is entirely useless He should provide himself with a white enamel dish (10 in x 8 in) an ordinary table spoon an ordinary bath tin a hand net and a *well larval net* A *well net* consists of muslin spread loosely over a loop of iron wire

about 15 in in diameter To the loop are attached three chains about 2 ft in length which in turn are secured to a small ring above To the small ring a suitable rope is tied so that the net can be lowered to any required depth A hand net consists of a similar net of smaller dimensions attached to a handle Armed with these implements the searcher should observe carefully the surface of small shallow collections of water which have been in existence for some time If larvæ are present tiny ripples are caused on the surface of the water by their movements and they can actually be seen swimming about or resting near the edges of the pools with the tail touching the edge and head facing the centre If there are any floating weeds in the water larvæ may be found clinging to the weeds It may so happen that at the time when a pool is inspected *all the larvæ may be resting at the bottom and none* will be seen at the surface It must not be concluded that the pool is free from larvæ By stirring up the water vigorously with the spoon and examining the surface again larvæ if present will be made clearly visible against the muddy water Where the surface of the water is covered with vegetation what is known as the dipping method should be tried By means of the bath tin the water from as close to the vegetation as possible is transferred along with any vegetation to the

enamel dish The water is allowed to remain a few seconds in the dish when larvæ if present will be seen coming up to the surface By far the best way of searching a pool is by using the hand net and the method employed is to fill about half of the enamel dish with water free from larvæ and put the net in several places in the pool and search round first at the surface then at the edges and finally deep in the pool Care should be taken not to allow the larvæ caught in the net to escape The net is then withdrawn and inverted into the enamel dish when larvæ if present will be seen in the clear water The operation should be repeated several times before a pool is pronounced free from larvæ For wells water cisterns etc, where any of the above methods will not be satisfactory the well net is used by lowering it at several spots into the water and inverting it into the dish containing clear water If larvæ are present they can be seen in the dish

Larvæ have been known to thrive in all sorts of water collections from the freshest rain water to pure sea water from the tiniest collections of water between the axils of the leaves of certain plants to large ponds swamps and rivers Therefore no water must be ignored but each collection should be systematically searched and experience will show in what surprisingly odd places mosquitoes will breed

The Imago or adult mosquito can be captured in one of two ways Either search can be made for him in his resting place or else he may be caught on the wing In the former case the apparatus required will consist of specimen tubes and cotton wool with which to plug the ends of the tubes Having carefully observed the mosquito resting on a wall in a cupboard or on clothes the pledget of wool is removed from the end of the specimen tube which is passed carefully but slowly over the mosquito and then the pledget of cotton wool is slipped underneath the tube so as to block the entrance If the cotton wool is pushed half way down another mosquito may be captured in the same tube if desired When mosquitoes are flying about a hand net fashioned like a butterfly net is required in addition to the glass tube The net is passed over the flying mosquito by a sweeping movement and the exit is immediately closed by gripping the outside of the net near the entrance with the free hand With a little manipulation mosquitoes caught in this way can be passed into tubes and secured by a cotton wool plug as has already been described Should the specimens only be required for mounting it will not be necessary to catch them in a tube simply place some chloroform on a pledget of cotton wool inside the net and all the specimens will be dead in a few minutes and they will be ready for mounting

A most thorough inspection must be undertaken before any building can be pronounced free of adult mosquitoes In Indian villages all huts must be carefully examined The thatch of these huts is a favourite resting place and very often the colour of the thatch coincides with that of the mosquito and it requires careful searching for their detection In almost every house in an Indian village a huge basket in which grain is stored, will be discovered in one corner The inside of the basket is smeared with cow dung which gives it a dull grey appearance There appears to be some curious attraction for mosquitoes there and usually large numbers can be discovered resting in these baskets Adults should be destroyed wherever possible but unfortunately no satisfactory trap has been devised that will attract them in really large numbers Several situations may be mentioned where mosquitoes are likely to be found and among them are to be noted all cow sheds and outhouses under the eaves of huts and in dark corners of houses especially on any cobwebs discovered there Mosquitoes have a curious fancy for dark and grey clothes and for the inside of leather boots and the under surface of saddles What the attraction is has not been satisfactorily explained Some authorities think that the colour is the attraction, while others suggest that the odour of certain articles for

example boots is what they like Basements and cellars are likely places to find the Imago and in certain countries they have been known to hibernate in them throughout the cold weather The uses to which an adult catch can be put besides the attempted reduction in total numbers are the identification of species in a given area the registration of houses barracks and so on where the largest numbers can be caught and at what periods of the year each species is most abundant But there is a much more important observation to be made from such a catch Large numbers of *Anophelini* thus caught are dissected with a view to determining what species carry the plasmodia of malaria and which of these species are the chief culprits Having determined these facts and knowing the habits of the species involved we can locate their breeding places and make anti mosquito plans

In carrying through such a scheme there are several points which must be carefully observed It must be remembered that anti mosquito campaigns involve expenditure and unless adequate provision is made in the beginning to incur such expenditure such schemes will only end in discredit to the personnel concerned Half hearted measures are worse than useless and are more a pretence than an earnest attempt at prevention of malaria

An anti mosquito campaign once started can never cease just as much as conservancy arrangements cannot cease and must go on indefinitely We cannot hope to exterminate mosquitoes once and for ever until we reach a state of civilization much higher than the present In the meanwhile war against mosquitoes has got to be continued without abatement and then only shall we succeed in reducing their numbers to any appreciable extent The officer entrusted with the conduct of the campaign should be made solely responsible for it Undivided responsibility in anti malarial operations is an asset the value of which cannot be lightly ignored Where different parties are concerned in a particular locality and unification of responsibility cannot for various reasons be attained a committee composed of the representatives of the different parties should be formed and thus ensure the closest co operation of all concerned

One cannot too strongly emphasize the importance of selecting the personnel Every endeavour should be made to get the right sort from the chief officer down to the men of the anti mosquito gang on the intelligence and honesty fo these much of the success or failure of a scheme will depend The officer should not be hampered by too much office work and by other duties but should have ample time for outdoor personal

work to check the duties of those working under him The subordinate staff should be well trained in a knowledge of mosquitoes their life history and habits they should know how to detect the presence of larvæ how to hatch them out and mount them, how to make an adult catch and even to be able to recognize the commoner kinds of *Anophelini* in the locality Anti malarial schemes should be backed up by proper legis lation though this might be used as a last resource Owing to the inadequacy of punishment given by legislators for sanitary contraventions some wilful and recalcitrant people would rather under go the punishment than obey sanitary rules Deterrent punishments and the disallowing of endless petitions will soon put a stop to this

The actual anti mosquito campaign may be broadly divided into major and minor works

Major works such as large drainage schemes diverting streams and channels or filling up large swamps will usually require a considerable capital outlay in addition to the recurring expenditure for their upkeep Whether it will be more econo mical to do the major works or minor works in the first instance should be decided at a very early stage of the campaign in consultation with the engineers taking into due consideration the species of *Anophelini* present their known habits and the conditions under which they are found

in any particular locality Engineering skill exhibited in ignorance or in defiance of the knowledge of local *Anophelini* often ends in expenditure *without any resulting benefit*

Under the heading of minor works we include such measures as systematic inspections and the use of larvacides draining or filling up of casual water collections rendering wells and water cisterns mosquito proof by screening them, filling up tree holes and so on

The area to be controlled is divided into six sections corresponding to six working days of the week and one section is dealt with on each day By the end of the week the whole area is covered and the following week the process is repeated and the different sections are inspected in the same order Each such area is entrusted to one inspector who will have a certain number of men working under him, depending on the nature of the work to be done If it is a large tract of country that is being controlled there will naturally be several such areas each under an inspector The advantages of visiting the sections in a particular order are that there is less chance of omitting any section if such a *routine* method is followed and the inhabitants, if any, of that particular section know exactly when to expect the visit of the anti mosquito squad During these inspections all possible breeding

MOSQUITO PROOF

A well w th ceme t d me

A MO QUITO PROOF TANK

O rfl w pipe ered w th wi ga e
b l l t pip m t d at y t w th t k
c. Cl htti g i d to m h l

places are carefully looked for and dealt with as described The inspector who always carries with him a notebook and pencil will carefully note down such places as he finds breeding and he will take samples of all larvæ For this pur pose he will have with him several numbered glass bottles and in these larvæ will be sent back to the laboratory for identification He will note such permanent places as wells cesspits and water cisterns where he discovers larvæ and report the fact to the officer in charge of his area There are however many occasions where the breeding can be dealt with on the spot It is then usually occurring in temporary breeding places He will order his squad to spray oil on a cesspit to drain away casual water or to fill up a puddle with earth He sees that all barrels or tins are emptied of any water they contain The barrels he has turned upside down and old tins and odds and ends are col lected for disposal by the sweepers concerned

The permanent breeding places are dealt with in various ways The squad should clear up drains and water channels freeing them from rub-bish and undergrowth If breeding is found in them they are sprayed freely with oil Water channels should be emptied of water at least once a week and the channels cleaned out In order to prevent water from accumulating in holes in such

channels they should be constructed of cement or the water should be laid on in pipes It must be carefully noted that when oil or Cresol or any other such larvacide is used a very essential part of the procedure will be the employment of a coolie to walk behind the person spraying the oil He will intimately mix the water and larvacide by vigorously stirring up the water with a sweeper s broom This is of the utmost importance if good results are to come from the use of larvacides Garden tanks for holding water, with which the *mali* waters the garden can be dealt with in various ways but the first essential is that it must never, in whole or in part be below the surface of the ground If it is then it cannot be properly emptied and if it is not emptied it is sure to breed The best type of tank is one built of masonry above ground Its dimensions are of little importance but one thing is essential namely the provision of an outlet pipe provided with a tap placed low down so as to drain the tank On his round every week the inspector must see all these tanks empty or else empty them himself The householders will readily agree to see that the tank is emptied each evening by the *mali* and that there is no water in it on the day of the inspection The substitution of hosepipes for tanks should be encouraged as much as possible Ornamental fountains are the scourge of the

inspector but the addition of those fish which are the natural enemies of mosquito larvæ will usually stop any breeding occurring in them House holders should be warned of the necessity of feed ing those fish and the inspector will make a point of seeing that they are alive and sufficiently numerous on his weekly round He should replenish them as may be necessary The fountains should be kept clear of water lilies and other vegetation which will provide protection for larvæ

Where a laid-on water supply exists a cement platform should be built under each stand pipe The edge should be raised about six inches and the water tap should overhang the trough The trough should be drained by a properly con structed drain with a gully trap The drain should be connected with the general drainage system where such exists or should lead to a properly constructed soakage pit No puddles should be permitted to exist near a stand pipe This gully trap is inspected and oiled every week as a routine measure Cisterns are usually provided for each bungalow or group of bunga lows where there is laid-on water It is to be found either under the rafters of the roof or raised on a platform to the requisite height in the compound These tanks should receive special care and should be rendered mosquito

proof There are always two and sometimes three openings through which the Imago may gain entrance There is the manhole, this should be provided with a properly fitting lid which is kept padlocked *If necessary the edges* of the lid may be cemented over so that no space can be left between the lid and the tank The overflow pipe must be provided with wire gauze over the outlet so that no female mosquito can gain entrance by it A third entrance may be discovered where the inflow of water takes place This pipe should be bolted to the upper edge of one side of the tank but sometimes it is thrust through a hole in the top When this is so cement should block up the gap between the pipe and the lid All tanks not mosquito proof will be reported on by the inspector

Wells may present great difficulty in India where they are in common use In Colaba they have now been completely covered over by dome shaped masonry work This is a cheap and *efficacious method and has much to commend* it The well cannot be opened as the lid of the man hole is bolted down and the dome prevents either water or rubbish collecting on top of the cover Wells have usually a semi religious and semi magic significance attached to them and the complete closing of a well used for drinking purposes is objected to because fresh air and

light cannot gain admittance to the water. This difficulty may be overcome by raising the sides of the well some six or eight feet high and roofing it with wire gauze. The water is withdrawn from the well by some form of hand pump similar to that employed in England. Wells which are used for the provision of water for irrigating land present a much more acute problem, and the best suggestion we can offer is the covering of the well and the provision of an internal combustion engine geared to a centrifugal pump. Whatever solution there may be to this problem, one fact from an anti mosquito point of view must not be lost sight of, and that is that wells in India are the permanent breeding grounds of the *A. stephensi* which is a notorious carrier of the parasites of malaria, and if anti mosquito measures are to be successful such wells as breed this insect must be rendered mosquito proof. During their weekly inspection it is the duty of the anti mosquito gang to inspect the water seals of wash-down water closets. Those not in daily use should be oiled and a film of oil should be spread over the surface of the water in the cisterns above them.

Vessels containing water inside houses should be emptied daily. Amongst them are not to be be overlooked flower vases and *chattie*. Instead of water in antiformicas we would recommend cresol or if the smell is objected to oil. They

are quite as efficacious in preventing ants swarming up on to tables or into meat safes and they do not breed mosquitoes They have the additional advantage of requiring very little attention One of the most constant casual breeding places is the rain water gutter which is very often found on buildings in India During rains these become choked with dirt and grow weeds Thus water collects in little pools in them No building in India should have a rain gutter The water should run directly off the roof to fall on a cement ledge on the ground level The outside edge of this ledge should have a channel to lead away the water Where there are flat roofs water often lies about on them during the rains This water should be brushed off at least once in ten days

All gully traps connected with a drainage system must be oiled and if a cesspit be found in the courtyard of a house this must be inspected to see that it is properly constructed and rendered mosquito proof All inspection chambers should be inspected to see that the covers fit properly and if they do not then they must be opened and searched for mosquito larvæ Defective covers are reported on by the inspector *The handlegrips in the lids of manholes* and other such covers are cup shaped depressions crossed by a bar of iron These depressions

constantly become filled with rain water and form common temporary breeding places They should be filled with earth or cement

Gardens especially untidy ones require the attention of the inspector Undergrowth and long grass should be forbidden anywhere near human habitations They provide excellent shade for the Imago during the day and conceal all sorts of rubbish capable of holding water Certain plants collect and store water at the junction of the stem with the leaf The tiger lily commonly seen in Indian gardens is such a plant we frequently have found it breeding mosquitoes Such plants should not be grown in gardens Trees in the area under control should be inspected carefully once a year and all hollows in them filled with a mixture of one part cement to two parts sand When the holes are very large they are partially filled with stones and then covered with cement Very seldom is it necessary to cut down trees All trees inspected should be marked with a white cross while such trees as are found breeding should be indicated in addition with a red cross

On the day preceding the inspection of a section one man is detailed to go round and collect all tins and odds and ends lying about He deposits them so that they can be removed by the scavengers on their rounds He also hands in at each bungalow a questionnaire card (*cf* Appendix VI)

on which the occupant is asked to state whether he is troubled with mosquitoes or not. This card is dated and initialled. It is returned to the inspector when he calls next day on his inspection. These cards were started in Colaba with a view to *finding out where mosquitoes were most troublesome*. One surprising result has been the regularity with which they have been filled up by civilian and military inhabitants. There is no compulsion about these cards and the housewife has on many occasions asked after her card should she not have received one. They usually give the *first indication of any outbreak of mosquitoes*. It is also a rough and ready guide to the inspector *of the progress of his work and informs him to* what sections he should give special attention. If he is unable to detect any breeding place there he reports accordingly to his officer who takes the matter up and gives this particular area his careful attention. In a large majority of cases where complaints are made about mosquitoes breeding can be detected in the immediate surroundings.

The inspector returning from his rounds will that day enter all records made in his notebook in the book at the office provided for that purpose. Each section of an area has a book and under the date of the inspection he will enter the exact position of any breeding places discovered, the nature of the water where

found breeding for example a tin in the npound a well a cistern or a brackish water ol as the case may be Matters he has noticed quiring attention beyond his power to correct l be entered up for the information of the cer in charge who will take such action as he y deem expedient The inspector also intains a chart (*vide* Appendix V) which shows division of the area into sections and the ys on which each section is visited This rt will be kept up to date A spot map maintained for each section concerned and enever breeding is detected it is ndicated by listinctive spot according as to whether the ve are of the genus *Anopheles Culex* or *Stego ia* Such methods as the above lead to stematic work on the part of the inspectors and d to avoid confusion which would be disastrous the ends in view

The progress of an anti mosquito campaign is gistered by the incidence of malaria occurring hospitals and dispensaries A more accurate imation of the amount of malaria in a given trict in shown by the incidence among the ldren of that area between the ages of two and n years One of the symptoms of malaria is an larged spleen and children of these tender rs are very susceptible to the disease and en they are attacked by it their spleens become

enlarged and so long as they suffer from it remain so sometimes reaching an enormous size. The reduction in the percentage of children with an enlarged spleen is a sure indication that a campaign is progressing favourably. From rather complicated calculations a figure is arrived at which is called the Splenic Index. This index shows the prevalence of malaria in a district.

In conclusion we would draw attention to the subject of propaganda work by which the interest of the general public may be aroused. Although it is not likely to be effective by itself yet it might here and there appeal to the more intelligent who would press for greater co operation between the public and sanitary authorities. While anti mosquito measures must always be supported by public opinion yet it is the duty of all who have knowledge of the ravages of malaria to educate and arouse that opinion until we reach such a stage of civilization that we will look upon the mosquito as a noxious insect not to be tolerated in our midst. In the same way as we look back a few generations and wonder with disgust how our respected ancestors ever permitted themselves to be the hosts of loathsome bodily parasites so will future generations be astonished at the many makeshift and ineffectual measures that we adopt to day to avoid malaria and yet allow mosquitoes to dwell in our habitations.

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APPENDIXES

APPENDIX I

HOW TO SEND LARVÆ AND LARVAL SKINS FOR PURPOSE OF IDENTIFICATION AND DESCRIPTION

FULL GROWN larvæ are isolated by placing them in tubes Only one larva should be placed in each tube When pupation takes place the larval skin is cast in the water complete with all the hairs and chitinous parts the skin is *carefully poured off with a little water into a clean petri* dish the pupa being left in the original tube with some water The skin is carefully lifted from the water by means of a small slip of filter paper and transferred to a small tube containing a mixture of formalin and water *(about 10 per cent formalin) This small tube containing* the skin is numbered by placing a number on a small slip of paper in the top of the tube a similar number on another slip is put in the top of the tube containing the pupa being held in place by a plug of cotton wool this plug also *serves to prevent the escape of the mosquito* when it emerges When emergence has taken place the mosquito is transferred to a clean tube by holding the latter with its mouth to that of the former tube after removing the plug The plug is then pushed into the mouth of *the tube containing the mosquito and* a few drops of chloroform poured upon it the mosquito is then mounted in the usual way and a small label attached to the pin corresponding to the number of the larval skin from which this mosquito resulted The mosquitoes and the skins can be sent in their respective tubes by post. The small tubes containing liquid should be filled up to the cork and if possible sealed with wax by dipping the top of each tube into melted wax

APPENDIX II

HOW TO MOUNT AND PRESERVE MOSQUITOES

APPARATUS REQUIRED

1. Specimen tubes with corks
2. Fine double pointed nickel pins No 3
3. Cork sheets
4. Cardboard
5. Forceps with grooved teeth at the tip

First prepare your specimen tubes as follows

Paste white paper on to a cork sheet and cut it into small strips just broad enough to go inside the specimen tubes Attach a strip to the cork of the specimen tube by passing an ordinary pin on either side from the strip to the cork The cork strip when thus fixed to the cork of the tube should not touch the bottom of the tube but just clear it Make a small triangular slit on one side of the cork of the specimen tube so that a small groove exists between the cork and the glass and into this groove fix a pledget of cotton wool The tube is now ready for receiving the specimen Place the mosquito upon its back on the card board Hold the pin about the middle with the forceps and push one end steadily through the thorax so that it just emerges from the centre of the dorsum of the thorax The mosquito is now transfixed to one end of the pin lift the pin and transfix the other end to the cork strip of the prepared specimen tube In this way about ten mosquitoes can be mounted and preserved in each tube Put a few drops of pure carbolic acid on the cotton wool plug Put carbolic acid on the plug once a month and this will prevent the specimens getting mouldy

APPENDIX III

HOW TO HATCH OUT MOSQUITOES FROM LARVÆ

PLACE the larvæ in a white enamelled basin containing some of the water in which they were found Keep them there till they become pupæ when they should be removed from the basin to wide mouthed glass bottles filled three fourths with water and over the neck of which a piece of mosquito-netting is tied

The mosquito netting retains the emerging adults

APPENDIX IV

HOW TO MAKE A CLEAR AND PERMANENT PREPARATION OF LARVÆ

METHOD I

Put the larva in a test tube and pour a few drops of caustic potash or soda (2 to 5 per cent) solution in water

Boil for a few minutes when clear transfer the whole into a watch glass pour off potash solution wash in distilled water two or three times Then transfer the larva to 50 per cent alcohol keep for five minutes then transfer it to 70 per cent alcohol Keep there for 5 or 10 minutes then transfer to absolute alcohol and keep for 15 to 30 minutes During all these processes never allow specimen to get dry It is better to change the absolute alcohol two or three times

From absolute alcohol place it in a drop or two of clove oil till it is sufficiently clear (about 5 to 10 minutes) when clear remove with a pin or brush to a slide and put a drop of Canada balsam over it and with needles manipulate the position in which you want the larva then cover with a cover slip

METHOD II

Put the larva in a watch glass containing 10 per cent formalin When dead transfer it to another watch glass containing alsolute alcohol so as to dehydrate it then transfer it to clove oil or oil of wintergreen and when clear mount in balsam Two strips of cardboard placed under the cover glass will support it

DAILY ROUTINE OF ANTIMALARIAL WORK FOR THE MONTH OF 192

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Area A																												
Area B																												
Area C																												
Area D																												
Area E																												
Area F																												

APPENDIX VI

QUESTIONNAIRE CARD

Bungalow No

Occupant's Name

Are You Troubled by Mosquitoes?

On presentation of this card please state Yes or No and sign your name

Date	Yes	No	Signature

APPENDIX VII

TABLE FOR IDENTIFYING THE FEMALES OF THE *ANOPHELINES* OF INDIA

N B —Always make certain that the specimen examined is a female *Anopheline* Special att nto n is drawn t the N tes at the end of the table

I WINGS UNSPOTTED

A DISTINCT WHITE KNEE SPOTS AT DISTAL ENDS OF HI D FEMORA (NOTE 7)

A plumb a var b rianen s

B NO DEFINITE K IEE SPOTS

1 Head scales very narrow linear Palps very thin Anterior forked cell nearly double posterior (Note 7)

A tk n

2 Head scales expanded as in ordinary *Anopheles* Palps not very thin Anterior forked cell re latively shorter (No e 7)

A cul fo m s

II WINGS SPOTTED

A TIPS OF HIND LEGS WHITE
(If not white see p 96)

1 Femora and Tibiae not Speckled (Note 1)
(If speckled see p 95)

a At least the two terminal tarsal segments of the hind legs *completely* white (Notes 2 and 7)

(i) Dorsum of abdomen heavily clothed with pale scales projecting at the sides to form tufts on all segments — **A pulcherrimus**

(ii) Dorsum of abdomen not so clothed No lateral scale tufts

Fifth vein of wing pale in the greater part of its extent (Note 7)

Ventral aspect of most of the abdominal segments with scattered pale scales Distal end of first hind tarsal segment never picked out with white (Note 7) — **A pallidus**

Ventral aspect of abdominal segments not so Distal end of first hind tarsal segment variable usually picked out with white (Note 7) — **A. philippinensis**

Fifth vein of wing mostly dark Distal end of first hind tarsal segment conspicuously picked out with white (Note 7) — **A fuliginosus**

b Only the terminal hind tarsal segment *completely* white (Notes 2 and 3) Four white bands on each palp including apical band (Note 7) — **A karwari**

2 Femora and Tibiae Speckled (Note 1)
(If not speckled see p 94)

a Two or three terminal tarsal segments of hind legs *completely* white (Notes ? and ?)

(i) Each palp with t b ad p l t l l nd nd one narr pr im l n (N t 7)

Three ter inal h n l t l s g nts om plet l *ch te (Notes d) P lps pro t nently sp ckl d (N te 4)*
A m c l p lp s i nd n

Fu ter t l li t ti l seg e ts l compl tely *hite (N t s d) I ad h te ba d b e ll s Pilps t spe kl d (N te 4)*
A th bald

(ii) Each palp ith ne br l p l pi al band and t o narrow m r pr x n l (N t)
A j m

b Less than two terminal tar al segments t hind legs *completely* white (N te and)

(i) Each palp ith f r ll rk d p l t nd in cludi g pi l b d (N t 5 a 1)

Thre dark p l l s th l itud l ter of a g C sp s hl k s le ll o te t l s rf e t ll t t t l s g e l H lf of te l i l t s l e t ly white (N te 7) **A ko h**

F e d k sp t th l gil f ter of a g O t t p l l l ht d t s l seg e t (N t 7)

Lit t r j l t t hin l l g l ro. lly l or p rk l h le l th l t
A l u o phyru

F b o-ars l y t f l i l l th ut u h br d banl **A t latu**

(ii) F ch palp with three p l band n lud p al band (Notes 5 1)

D rs i of n o t of the bd t l segr e ts thi kly cl thed with scales **A w llmori**

Scales if present estricted to the last few abdomin l segments ly **A maculatus**

B TIPS OF HIND LEGS NOT WHITE

1 Femora and Tibiae not Speckled (Note 1)
(If speckled see p 98)

a *Less than four dark areas on costa involving both the costa and the first longitudinal vein of wing (Note 7)*

(i) Inner half of costa without any distinct pale interruption (Note 7)

Broad white band on femur of hind leg

With prominent scale tuft associated with the band **A annandale**

Without such a tuft **A lindesa**

No broad white band on femur of hind leg

Palps with some pale bands **A hyrcanus var nigerrimus**

Palps with no pale band

With prominent scale tuft on ventral surface of eleventh abdominal segment **A barbirostris**

With no such scale tuft **A umbrosus**

(ii) Inner half of costa with pale interruption (Note 7) **A gigas**

b *At least four dark areas on costa involving both the costa and the first longitudinal vein of wing (Note 7)*

(i) Front tarsal joints with broad pale bands (Note 7)
(If without see p 97)

Palps with dark pre apical area equal to or nearly equal to pale apical band (Note 7) **A subpictus (rossii)**

Palps with dark pre apical area half or less than half the length of the pale apical band (Note 7) **A vagus**

(ii) Front tarsal joints without bro d pale band
(If with see p 96)

Tips of palps black

Dorsum of thorax with hairs or n trow false scales Sixth wing v in with ery ind fin te mark ngs (Note 7) **A turkhudi**

Dorsum of thor x ith obvious ue scales S xth wing vein ith ery def n te marking (three dark spots) (Note 7) **A mult ol**

Tips of palps not black

Third longitudinal v ing ein dark (N t)

No pale spots on ui g veins other tl a those o costa (Note 7) **A hode en is**

Pale spots prese t on other ve s **A cul fa**

Third longit d n l ving in light (N t 7)

Each pilp v th two alt ost equ l bro d p l dist l bands and a r a p t l e (N te 7)

Proboscis pal in ap l half S x h ing ei with th dark pot (N t 7) **A a on t s**

Pr bosci not s Sixth ing e n th t vo dark spot (N t) **A m n mus**

Palps not so

Inn r qu rte f costa with t p l int rupti (Note 7) S les present nly n th xtrem front of d rsum of th r **A l ton**

Inner q ia ter f t ith pal n errupti n (N te 7) Scales p esent er m st ct lors m f th rax

Longest pale i a sta less th half the le igth of longest da k i ea (N te 7) Ta si of h nd legs ust ally n rrowly b t disti ctly ba ded a th u h le **A hyporien s**

Longest pal a a osta very l ttle sh ter th in l ngest da k e (Note) T rs of l nd legs not b ided tl s **A superp tu**

2 Femora and Tibiae Speckled (Note 1)

(If not speckled see p 96)

a Each palp with four well marked pale bands including apical band (Notes 5 and 7)

(i) Tibio tarsal joint of hind leg broadly and conspicuously banded with white **A leucosphyrus**

(ii) Tibio-tarsal joint of hind leg without such broad band **A tesselatus**

b Each palp with three well marked pale bands including apical band (Notes 5 and 7)

(i) Each palp with two broad distal and one narrow proximal band (Note 7) Palps speckled (Note 4) **A stephensi**

(ii) Each palp with one broad apical and two narrow more proximal band (Note 7) Palp not speckled (Note 4) **A. ludlowi**

NOTES TO PRECEDING TABLE

Note 1 A faint mottling is not considered as *speckling* Seen under the microscope the spots constituting speckling are always clearly defined areas of pale scales

Note Tarsal segments *completely* white are counted from the tip of the leg *stopping at the first dark band*

Note 3 In this case there a ually ht re f rm g band higher up the tarsus

Note 4 *Speckling on the palps* refers to white spots on their dorsal surface usually between the middle and p m l pale bands

Note 5 *B uare of speckl g t t t o a f th band*

Note 6 Species entered in more than one place in the table may show sometimes one appearance and sometimes another or an appearance which may be e l ked In either case the table will work correctly

Note 7 The *first tarsal segment* that nearest to the tibia

Terminal segments are those at the tip of the leg

Hind tarsal segments t the e f hind legs

Front tarsal segments t a th f front legs

By *apical band* is meant n l ig the t m tp

Distal means situated furthest from the body

Proximal means situated re to the b l

The *costa* is the anterior border of the wing

The *first longitudinal v* rt n p r ll l tl th costa

The *second longitudinal vein* lies behind the first and divides into two branches

The *third longitudinal vein* lies behind the second and is unbranched

The *fourth longitudinal vein* l behind the third and divides into two branches

The *fifth longitudinal vein* l behind the fourth and divides into two branches

The *sixth longitudinal vein* lie behind the fifth and is unbranched

The *anterior forked cell* is the part of the wing lying between the branches of the second longitudinal n

The *posterior forked cell* he part of the wing lying between the branches of the fourth longitudinal vein

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